MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

ERT3036 – ADVANCED ROBOTICS

(RE)

(OPEN BOOK EXAMINATION)

23 OCTOBER 2018

9.00 a.m. – 11.00 a.m.

(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of five (5) pages including this cover page with four (4) Questions only.

2. Attempt all **FOUR (4)** questions. The distribution of the marks for each question is given.

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3. Please write all your answers clearly in the answer booklet provided.

Question 1

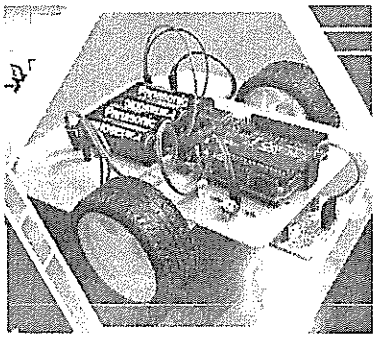

Figure Q1 A differentially driven wheeled mobile robot for MMU Robotics Challenge. (Picture source: https://goo.gl/uMF9k1)

A team of secondary school students participated in the preliminary round of the MMU Robotics Challenge 2018 using the robot as shown in Figure Q1.

a) State whether the robot is a holonomic or a non-holonomic system. Explain the two terms to justify your answer. [6 marks]

b) Spring loaded encoders are attached to both wheels to ensure that the robot is always in contact with the floor. q_1 is the incremental encoder reading for wheel 1 (left wheel) and q_2 is the reading for wheel 2 (right wheel). The encoders are similar and produce 360 pulses for each rotation of the wheel. The two wheels are separated by 10 cm and the wheel radius is 2 cm.

i) The robot can only move in straight or circular manners. When the instantaneous radius of curvature, R_i = 2 m and the robot makes a total of 18 degrees (π/10 radian) turn in the clockwise direction, how many pulses are measured by q_1 and q_2 respectively? [8 marks]

ii) After the action in (i) above, the mobile robot changes to clockwise rotation of R_i = 5 m. This is made possible by changing the linear wheel velocities v_1 and v_2 respectively. Find the ratio of the wheel velocities, v_2/v_1 when this occurs. [3 marks]

c) The robot is located at point P with coordinates (3 m, 5 m) in the x-y coordinate frame with an orientation of 0 degrees with respect to the y-axis. Point P is the mid-point of the robot along its differential drive axis. The goal position is located at point G with coordinates (1 m, 0 m). The width of the mobile robot, w is 0.1 m and the length, L is 0.6 m.

A circular obstacle with a radius of 0.5m is located at point T (2 m, 2 m). You will use artificial potential field (APF) method to perform obstacle avoidance.

i) Plot a graph to show the robot, the goal and the obstacle. [4 marks]
ii) Briefly describe how the robot reaches its goal. [4 marks]

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Question 2

a) Give a brief description for each of the following:

i) Serial robot arm [6 marks]

ii) Parallel robot arm [6 marks]

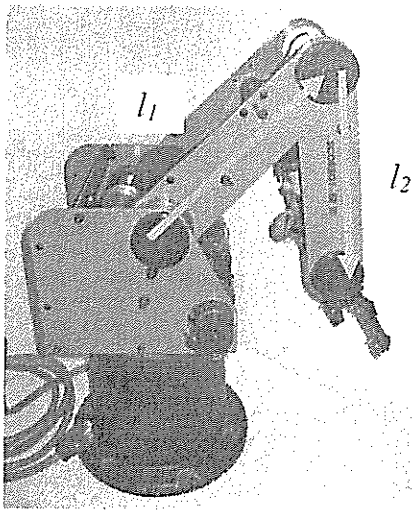

Figure Q2 Scorbot ER-4U Serial Robot Arm
(Picture source: https://goo.gl/wkxaZz)

b) The Scorbot shown in Figure Q2 can be represented as a two-link robot in the sagittal plane.

The equation of motion for such an arm pivoting at the origin $(x,z) = (0,0)$ can be derived using Lagrange formulation. Assume that for link 1 its length is l_1, mass is m_1, moment of inertia is I_1; and for link 2, the length is l_2, mass is m_2, and the moment of inertia is I_2.

i) Find the square of the velocities of the centre of mass for both link 1 and link 2, i.e. $\dot{x}_1^2$, $\dot{z}_1^2$, $\dot{x}_2^2$ and $\dot{z}_2^2$. [9 marks]

ii) Evaluate the kinetic energy, K_1 , K_2 for link 1 and link 2. [4 marks]

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Question 3

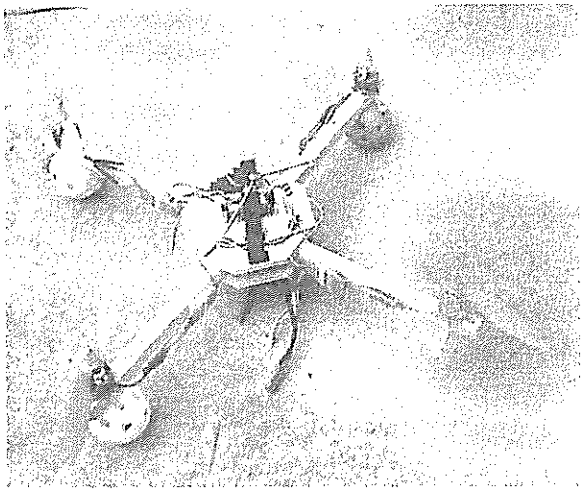

Figure Q3 A DIY quadcopter ready to take off vertically
(Picture source: https://goo.gl/432Lfz)

a) A do-it-youself (DIY) quadrotor is resting on the floor. Propose a sequence of control to the quadrotor such that it can take off vertically to a height, z_o . hover and then fly horizontally while maintaining its height and stop for hovering again. The mass of the quadrotor is M. Motor 1 and Motor 3 are along the x-axis and generating lifting force of F_1 and F_3. Motor 2 and Motor 4 are along the y-axis and generating lifting force of F_2 and F_4. Declare all other necessary parameters that you are introducing.

[16 marks]

b) Four ball like cushions are attached under each motor to protect the quadrotor while landing. Propose a landing control so that the cushions experience minimum force when it lands on the floor again. [9 marks]

Continued ...

Question 4

a) Under Industrial Revolution 4.0 (IR 4.0), robots are developed to perform many tasks autonomously. Among these robots, sociable robots are gaining popularity. Briefly describe three (3) robotic applications that use sociable robots with good results. [6 marks]

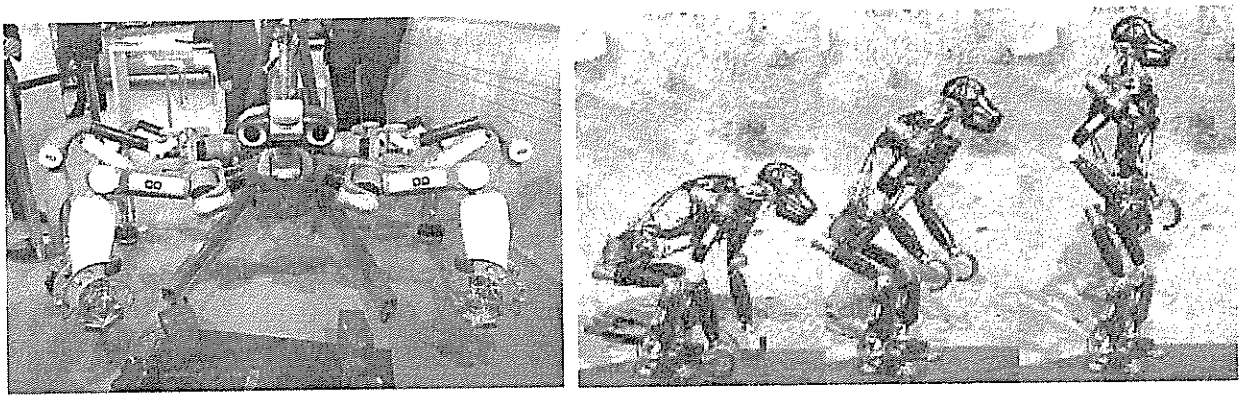

Figure Q4 Two advanced robotic systems are under research and development in the Robotics Innovation Centre, Germany 2018.

(Picture sources: https://goo.gl/MXfut7 , https://goo.gl/LHQQ3g)

b) Two of the advanced autonomous robotic systems are being developed in the DFKI Robotics Innovation Centre in Germany as shown in Figure Q4. Describe the salient characteristics of these two systems. [12 marks]

c) Professor Stephen Hawking was the famous theoretical physicist from the University of Cambridge. He repeatedly warned that artificial intelligence (AI) may evolve itself one day and threatened humanity. State the four robotic laws introduced by Issac Asimov that may be able to prevent this from happening. [7 marks]

End of Paper